TEACHERS' BELIEFS ABOUT STUDENTS' GENERALIZATION OF LEARNING

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Researchers in psychology and mathematics education have been conducting systematic investigations of students' generalization (or transfer) of learning since the beginning of the 20th century. However, we do not know how teachers, the people typically associated with student learning, think about this phenomenon. This study, thus, identified teachers' beliefs about students' generalization of learning. Five categories of teacher beliefs were identified, highlighting the importance of bringing teachers into the ongoing transfer conversation as the categories identified both extend current conceptualizations of transfer into the domain of mathematics education and identify new beliefs regarding students' transfer of learning.

INTRODUCTION

The idea that students generalize classroom learning to novel situations serves as the foundation for our educational system (Bassok & Holyoak, 1989; McKeough, Lupart, & Marini, 1995; National Research Council, 2000). One body of research that has examined students' generalization of learning is the research on *transfer* (e.g., Bereiter, 1995; Engle, 2006; Gick & Holyoak, 1983; Lobato, Rhodehamel, & Hohensee, 2012; Markman & Gentner, 2000; Singley & Anderson, 1989; Thorndike & Woodworth, 1901). Traditionally, transfer has been characterized as "how knowledge acquired from one task or situation can be applied to a different one" (Nokes, 2009, p. 2). Transfer has had a rich and varied history dating back to the turn of the 20th century and has evolved to include a multitude of perspectives regarding what transfer is, how it occurs, and how it might be supported. One might assume that since teachers are the people typically associated with student learning, some of the transfer literature would have identified teachers' beliefs about their students' generalization of learning. However, such studies do not appear to exist. Thus, I sought to determine whether teachers think about students' generalization of learning as part their typical practice and, more specifically, to answer the following question: What are teachers' beliefs regarding students' generalization of learning?

FRAMEWORK

As noted above, *transfer* has traditionally been conceived of in terms of the application of one's previously acquired knowledge. Heeding critiques of such acquisition-application views of transfer (e.g., Lave, 1988), researchers have reconceived of and redefined the phenomenon in many different ways (e.g., Bereiter, 1995; Lobato et al., 2012). Here, I use the term *transfer* to reference the phenomenon in which students generalize, extend, or in some way make use of their learning when

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engaging with novel situations (rather than in reference to a particular conception or definition of transfer).

This study identified teachers' *beliefs* about students' generalization (or transfer) of learning. Drawing upon Philipp's (2007) definition, I define *a belief* regarding transfer as a conception (i.e., a general notion or view) regarding transfer that I, the observer, can respect as intelligent and reasonable even when it differs from my own conceptions regarding transfer. Here, beliefs are distinguished from knowledge (i.e., conceptions that I can not respect as intelligent and reasonable when they differ from my own). This decision indicates my own orientation towards conceptions of transfer. The fact that transfer is one of the most researched topics in psychology coupled with the fact that many different conceptions of transfer are documented in the transfer literature leads me to believe that transfer is a complex phenomenon, best studied as a belief wherein I am supported in making sense of differing conceptions of transfer rather than casting them aside as unintelligent and/or unreasonable.

METHODS

Participants

I recruited eight practicing teachers from multiple urban school districts in Southern California to participate in this study. Teachers were selected on the basis of several criteria. First, *practicing* teachers were selected to help ensure the selection of teachers who, at the time of the study, naturally thought about the phenomenon of interest to this study. Second, participants were recruited on the basis of the nature of the mathematics courses they taught and whether they had the opportunity to develop students' understanding of slope during the 2011-2012 or 2012-2013 school year. (Slope provided the mathematical context in which teachers' beliefs were examined.) Finally, teachers were recruited so there was variation across the following: the forms of practice enacted in their classrooms, the number of years teaching experience, the amounts of training and professional development received, and the type of school where employed (charter school vs. non-charter school). The rationale for seeking such variation was to increase the chance of selecting a group of teachers who held different beliefs regarding students' generalization of learning.

Data collection

I engaged the eight practicing-teacher participants in two 2-hour semi-structured clinical interviews (Clement, 2000; Ginsburg, 1997). During these interviews, teachers were asked questions and posed tasks that were designed to elicit their beliefs regarding students' generalization of learning. The same major questions and tasks were posed to each teacher, but follow-up probes were tailored to individuals. The interviews were recorded with a video camera and a table microphone. The video camera was aimed to capture teachers' gestures, written inscriptions, and verbal reports. All written work and materials were collected.

Instruments

The major questions and tasks designed to get at teachers' beliefs about students' generalization of learning were separated into three sets: (a) questions related to an instructional item teachers selected and brought to the first interview, (b) questions and tasks designed to provide teachers with opportunities to explicitly *espouse* their beliefs regarding students' generalization of learning and me data from which to *infer* such beliefs, and (c) questions related to a lesson plan teachers constructed to support their students' generalization of learning. Each set is briefly discussed. (Note that because the word *transfer* is a researcher construct, it was not used with teachers; rather, phrases like "generalization of learning" were used.)

Prior to engaging in the first interview, I asked teachers to select an item or items (e.g., an activity, lesson plan, test, or homework) they had used during a unit on slope and linear functions that they believed demonstrated an instance in which they thought about supporting their students in being able to generalize their understanding of slope to a new task, activity, or situation. The discussion of this teaching item took place at the beginning of the first interview and involved questions like: "Describe how your [item] shows you were thinking about helping students to make future use of their learning." All of the teachers brought a task or activity involving slope and were thus asked questions like "As a consequence of your students' engagement with this [item], what types of tasks and activities do you believe your students are (and are not) prepared to successfully engage with?"

The second set of questions and tasks was not associated with either the aforementioned instructional item or the lesson plan still to be discussed. It involved more general questions like "What do you do, or what do you think teachers in general can do, to help enable students to be able to generalize their learning to new situations? Explain how these actions support students' generalization of learning." This set of questions also involved more specific tasks and questions including a task in which teachers were presented with hypothetical student responses to a slope task and a set of novel slope tasks, and asked to discuss which of the novel tasks the hypothetical students would be able to successfully engage with given their work. Teachers were also presented with three hypothetical instructional activities and asked to discuss which activities best supported students in generalizing their understanding of slope.

Between interviews, teachers were asked to develop a lesson plan on slope that implemented some of the ideas they discussed during the first interview regarding students' generalization of learning. They were also asked to design a novel task (not discussed in the lesson) with which their students could successfully engage after participating in the lesson. In the second interview, teachers' were asked questions about their lesson plans, novel tasks, and the relationship between the two.

Data analysis

I transcribed and analyzed all interview data qualitatively, using what Miles and Huberman (1994) describe as "partway between a priori and inductive coding" (p. 61).

Categorizing teachers' beliefs about students' generalization of learning involved drawing upon the transfer literature. For instance, some teachers appeared to believe that students would be able to productively generalize their learning to a novel situation if the novel situation prompts students to make use of a learned association, procedure, or formula—a belief found in the research literature from an associationist view of transfer and mainstream cognitive accounts of transfer (e.g., Singley & Anderson, 1989; Thorndike & Woodworth, 1901). Other categories of teachers' beliefs were induced using *open coding* from grounded theory (Strauss, 1987).

RESULTS

I identified five categories of teacher beliefs about students' generalization of learning. These categories fit within three super-categories: content, students' disposition, and students' affect (see Table 1). Content refers to the mathematically specific knowledge students generalize; students' disposition refers to the general orientation towards problem solving students generalize; students' affect refers to student-held beliefs that support students' generalization of learning. The number found within parentheses indicates the number of teachers holding a particular belief. (Note that teachers held multiple beliefs about students' generalization of learning.)

<table>
<tr><th>Content (7)</th><th>Students' Disposition (3)</th><th>Students' Affect (7)</th></tr>
<tr><td>Category 1:
Associations, Procedures, and Formulas (3)</td><td rowspan="2">Category 3:
Orientation towards Problem Solving (3)</td><td>Category 4:
Students' View of Self (6)</td></tr>
<tr><td>Category 2:
Meaning (4)</td><td>Category 5:
Students' View of Mathematics (3)</td></tr>
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Table 1: Categories of teachers' beliefs about students' generalization of learning.

Content

The first two categories of teachers' beliefs about students' generalization of learning involved the role of mathematical content. Specifically, 3 of the 8 teachers seemed to believe that students productively generalize their learning to a novel situation when the novel situation prompts the use of a learned association, procedure, or formula (Category 1). *Association* refers to students linking a specific word, phrase, or image to a particular mathematical response. *Procedure* refers to the use of a pre-determined set of steps to solve a problem. *Formula* refers to the employment of a conventional rule to solve a problem. For instance, Anne believed that students would productively generalize their learning to a novel activity that asked students to select appropriate graphs for given sentences like "We raced down the hill away from the museum" if they were prompted to make use of the associations she had previously instructed them to copy into their notes (e.g., "away" and an unlabeled graphical image of a diagonal line going up as one looks from left to right). She explained that if students focused on

phrases like "down the hill" rather than "away" when confronted with such sentences, they would not be prompted to make use of the learned association and would therefore be unsupported in choosing the correct graph. (Note that gender-preserving pseudonyms are used for all participants.)

In contrast, half of the teachers in the study seemed to believe that students' generalization of learning is based on the ways in which students interpret their mathematical activity and the *meanings* they develop for mathematical topics like slope (Category 2). Moreover, these teachers appeared to believe that students' productively generalize their learning when they develop mathematically-valid interpretations of topics like slope, for example, *slope is a ratio providing a description of the multiplicative relationship between two quantities*. Thus, teachers holding this belief made predictions about students' generalization of learning based on the meanings they thought students might develop for a particular topic rather than on whether they thought a particular task would prompt students to make use of a pre-determined association, procedure, or formula. For example, Patrick believed students would be able to find and explain the meaning of slope in a novel slope task involving a burning candle if, during previous classroom activities, they had developed an interpretation of slope as a ratio, or a multiplicative comparison, of two quantities. However, Patrick predicted that students who had not fully developed such an interpretation of slope would attend primarily to the height of the candle, saying a slope of -2.5 means "the candle is shrinking" or "the candle isn't as tall" rather than "the candle burns 2.5 cm *per hour*."

Students' disposition

Whereas teachers in the first two categories emphasized particular mathematical content in their beliefs about students' generalization of learning, the emphasis in this category was on students' more general dispositions toward problem solving. The term *disposition* is used in the spirit of Gainsburg (2007) to refer to students' personal outlook on or orientation towards problem solving; this includes what problem solving is about. Teachers seemed to believe that students productively generalize their learning to novel situations when they develop and make use of particular dispositions. Moreover, these teachers appeared to believe that the dispositions themselves carry over to novel situations and function to facilitate students' generalization of learning. For instance, Emma shared that students will be better able to "assess where to go" and "find the solution" in novel problem-solving situations if their orientation towards those situations is one of sense-making and visualization of the problem (e.g., by asking questions like "What is *actually* going on here?" rather than "What equation do I use to solve this—what is the formula?").

Students' affect

The last two categories of teachers' beliefs about students' generalization of learning involve the role of students' affect, specifically students' beliefs. To avoid confusion from using the word "belief" twice, I use the word "view" in reference to the students.

Hence, Category 4 involves teachers' beliefs regarding the role *students' view of self* plays in their generalization of learning and Category 5 involves teachers' beliefs regarding the role *students' view of mathematics* plays in their generalization of learning. This follows McLeod (1992) who conceived of both views of self and views of mathematics as components of the affective domain in mathematics.

Six of the 8 teachers in this study seemed to believe that students generalize their learning to novel situations when they develop confidence in their ability to engage in mathematical activity (Category 4). Here, confidence refers to a student's view of his or her "competence in mathematics" (McLeod, 1992, p. 583) or the "belief that one can learn to do that which is expected of one" (Broekmann, 1998, p. 18). These teachers believed that students' generalization of learning is dependent upon how confident a student is that he/she can engage in mathematical activity. For instance, Donna said, "It's hard to get kids to generalize [their learning] … because you have to break down their beliefs of 'I just suck at this; I don't know anything." She went on to say, "For me, it is making that 'Ah-ha' like 'Oh, I *can* do this.' … You have to build self-esteem into those learners like 'No, you're not stupid.'" Similarly, 3 of the 8 teachers in this study seemed to believe that students generalize their learning to novel situations when they view mathematics as relevant and useful outside of the mathematics classroom (Category 5).

These beliefs seemed vague in the sense that they were not well specified as mechanisms for supporting students' generalization of learning. It could be that the teachers in these categories believed students' views acted like a key to unlock the door to their engagement with new situations thereby creating an opportunity to apply particular mathematical understandings. Alternately, it could be that teachers believed students' views acted at a more general level allowing students to productively engage with new situations regardless of the particular mathematical topic. In this way, the limits of these beliefs regarding students' generalization of learning remain unclear.

CONCLUSION

The findings outlined above point to the importance of bringing teachers into the ongoing conversation regarding students' transfer of learning. Using artifacts from their own teaching, teachers were engaged in conversations about transfer using the terminology of students' "generalization of learning." This resulted in the identification of new beliefs about students' generalization of learning. In other words, talking to practicing teachers resulted in the identification of beliefs not found in the transfer literature. Looking across Categories 4 and 5 (see Table 1), the role of students' affect was present in 7 out of 8 of the teachers' beliefs about students' generalization of learning despite the fact that it is absent in the transfer literature. This finding indicates that while researchers have yet to identify affect as an important factor in the generalization of students' learning, teachers have.

This is not to say that overlap did not exist between teachers' and researchers' beliefs regarding students' generalization of learning. For example, Anne (from Category 1)

appeared to hold the Thorndikean belief that transfer is mediated by common associations (cf., Thorndike & Woodworth, 1901). However, the teaching items she selected to illustrate her belief were drawn from reform-oriented and constructivist-inspired textbooks suggesting practice-based decision-making that transcended a Thorndikean approach to curricula.

The Category 3 belief is similar to Bereiter's (1995) *dispositional* approach towards problem solving wherein Bereiter argued that students' "way of approaching things" is of primary concern when teaching for transfer (p. 23). Teachers holding this belief emphasized, in the spirit of Bereiter, the ways in which students orient towards problem solving and the roles their dispositions play in the generalization of their learning. However, Bereiter illustrated his ideas with examples from moral education and science education. Thus, the particular dispositions articulated by the teachers in this study (e.g., a visualization and sense-making disposition) are new to the transfer literature. In other words, by talking to teachers of mathematics, I was able to identify specific beliefs about dispositional approaches to transfer relevant to the field of mathematics education.

Lastly, the fact that all but one of the teachers appeared to hold multiple beliefs regarding students' generalization of learning suggests that *in practice* multiple beliefs about students' generalization of learning may actually function together. Together, these findings suggest that investigations into the transfer of student learning may benefit from a shift in point of view—from the eyes of researchers to the eyes of practicing teachers.

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